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Internationalization of the Petroleum Equipment Industry

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A Research Paper

PROJECT NUMBER GI-1491-85
I W M JR 1714
PAGE NUMBERS 36
TOTAL NUMBER OF COPIES 445
DISSEM DATE 85-07-30
EXTRA COPIES 295-319
RECORD CENTER 320-426
JOB NUMBER 100-857

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GI 85-10164
July 1985

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Internationalization of the Petroleum Equipment Industry



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A Research Paper

This paper was prepared by [redacted]
Office of Global Issues with technical assistance from
[redacted] Office of Soviet Analysis.
Comments and queries are welcome and may be
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OGI [redacted]

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Internationalization of the Petroleum Equipment Industry

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Summary

*Information available
as of 10 May 1985
was used in this report.*

US dominance of the worldwide petroleum equipment industry has eroded in the past 10 years largely because of the massive worldwide development of petroleum resources following the oil price rises of the early 1970s. Foreign governments and companies were quick to take advantage of this boom and the broad availability of US equipment and technology to build domestic petroleum equipment industries. Today, in a weak oil market and period of major equipment industry retrenchment, virtually all petroleum equipment can be purchased outside the United States from either foreign companies or US subsidiaries in a highly competitive marketplace. Many foreign companies have become effective competitors because of national policies that protect and nurture domestic industries, attractive financing, lower manufacturing costs, the strength of the dollar, and special political relationships with potential buyers.

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US companies and their foreign subsidiaries still retain their nearly complete worldwide market and technology dominance in some specialized but important sectors of the petroleum equipment industry that either embody exceptionally advanced technologies or are too small and capital intensive for foreign competitors to enter. These sectors include specialized geophysical equipment, advanced computers, high-pressure wellhead equipment, downhole completion gear, high-capacity electric submersible pumps, and gas lift valves. Even in most of these equipment sectors, foreign competition is present, but manufacturing capacity or field experience is limited. Among the industry sectors, where technology is less critical, US manufacturers continue to be the primary force in onshore drilling and production markets, although foreign competition is on the rise. The foreign petroleum industry generally has taken established US petroleum technology and adapted or improved on it as needed, especially offshore.

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The outlook for continued weakness in the world oil market during the rest of this decade is likely to lead to stronger foreign competition in the petroleum equipment industry, especially from government-supported Asian and West European companies able to offer attractive financing. New market opportunities will focus attention on deeper offshore and marginal field development, Arctic development, and, to a lesser extent, sales to Communist countries. Although more than half of all petroleum equipment expenditures in the non-Communist world over the next five years will continue to be spent in the United States—primarily onshore—worldwide offshore activities are playing an increasingly important role in the petroleum equipment market. We expect offshore construction activities will be

focused in the established North Sea and the Gulf of Mexico regions over the rest of the 1980s, with smaller programs in Canada, South America, and the Far East. Ambitious energy goals in both the USSR and China could mean a major expansion of Western business opportunities, although these national markets will remain a small part of the global petroleum equipment market well into the 1990s. []

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Increasing competitiveness in the international petroleum equipment industry and further weakening of US domination is likely to continue into the 1990s. In particular, we believe the vast lower end of the technology range of the world petroleum equipment, including the US market, increasingly will be penetrated by foreign engineering and construction firms and manufacturers. High-technology and specialized equipment requirements for particularly demanding conditions will still be dominated by US companies and their foreign subsidiaries, although competition will continue to increase from companies in Western Europe and Japan. []

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The broad international availability of petroleum equipment technology challenges the effectiveness of unilateral export—and potentially COCOM—controls on petroleum equipment. The knowledge to design and produce the vast majority of petroleum equipment is widespread, and enforcement of unilateral controls permits foreign companies to expand their market share. Countries seeking equipment covered by US unilateral export licensing controls can—in most cases—buy comparable equipment from foreign suppliers in Western Europe, Japan, and increasingly from suppliers in newly industrialized countries, such as Brazil, Mexico, Singapore, and South Korea, when they can not obtain it indirectly from the United States. []

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Even the effectiveness of COCOM controls on selected dual military and industrial use technologies embodied in some petroleum equipment may become ineffective as petroleum technology spreads. Advanced non-COCOM countries, such as Sweden and Finland, already produce some equipment controlled by COCOM. Increasing sophistication in electronics manufacturing in the newly industrialized countries—or acquisition of sophisticated components from developed countries—could give these countries the capability to produce COCOM-controlled petroleum equipment. Efforts to expand controls of exports on military-related petroleum technology from COCOM to non-COCOM countries could be extremely difficult because of trade pressures. []

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Despite the likely adverse trade consequences for the United States, the increased equipment manufacturing capacity worldwide—particularly in the oil production and transmission sectors—would permit quick expansion of production to replace damaged equipment if a major supply source is disrupted in the near future. The heightened competitiveness of the industry has led to reduced oil exploration and development investment costs, providing an incentive for more exploration and development, and an opportunity to reduce reliance on vulnerable oil sources, such as the Persian Gulf. The now global competition in petroleum equipment markets is also a strong inducement for innovation in petroleum equipment products and manufacturing techniques that is likely to be important in advancing petroleum production and reserves in the 1990s when most forecasters next anticipate a tight oil market.

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Norwegian-built concrete oil production platform in tow.

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Internationalization of the Petroleum Equipment Industry

Introduction

US companies traditionally have dominated the worldwide petroleum equipment industry, particularly in drilling, production, and refining and in state-of-the-art aspects of other industry sectors. This dominance evolved over several decades, beginning with the early growth of the domestic US oil industry—first onshore and later offshore. Even today, the United States accounts for approximately 80 percent of all wells drilled in the non-Communist world each year. Accustomed to dealing with US domestic equipment suppliers and confident in their products, major US oil companies continued their relationships with US equipment manufacturers or their foreign subsidiaries as they expanded their operations abroad. Until the 1970s foreign manufacturers were left with only a marginal share of the world drilling and production equipment markets and followed the lead of US technology in other areas such as exploration and transmission equipment.

During the last decade, the market dominance of US companies in many equipment categories has eroded. The massive development of petroleum resources worldwide following the price hikes of the 1970s created economic and political incentives leading to a rapid internationalization of the petroleum equipment supply business. Today, virtually all oil equipment can be purchased abroad in a highly competitive equipment marketplace, a change that may have important implications for US trade policies and international competitiveness well into the 1990s.

The Internationalization Process

Growing oil demand and rising oil prices in the 1970s caused an explosion of worldwide exploration and development activity—the greatest boom in the petroleum equipment business ever. Non-Communist world investment in all phases of the petroleum industry outside the United States soared from about \$17 billion in 1972 to about \$86 billion in 1982. During

the same period, US investment rose from \$10 billion to almost \$70 billion.

With US-controlled manufacturing capacity and technology stretched to its limits, major opportunities opened up for foreign manufacturers in both the advanced and newly industrialized countries. Foreign governments and companies quickly took advantage of this business boom and the broader availability of US equipment and technology to nurture their domestic petroleum equipment industries.

One of the most important forces in the internationalization process was the active role played by the governments of new oil-producing countries in requiring domestic participation in the oil industry through joint ventures, local content laws, and employment of host-country nationals. The primary goal of these policies was to develop an indigenous petroleum equipment industry that would:

- Acquire foreign—primarily US—capital and technology.
- Create local jobs in an expanding industrial sector.
- Reduce hard currency expenditures.
- Develop new export markets.
- Enhance national pride and prestige.

Aside from meeting government requirements, US companies were encouraged to establish foreign operations in new producing areas to take advantage of lower manufacturing costs, trade and tax advantages, and as a means of avoiding US export and trade restrictions. US equipment and engineering companies were quick to respond to these incentives in light of the potential economic gains. US technical and manufacturing know-how spread to foreign companies through a combination of licensing agreements, joint ventures, and foreign manufacturing or assembly operations. Today, major US equipment suppliers have more than 200 manufacturing facilities abroad, primarily in the industrialized world.

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Development of North Sea petroleum resources in the 1970s gave particular impetus to the transfer and assimilation of the most advanced US petroleum equipment and manufacturing technology. The scope of operations in Western Europe combined with the technical requirements associated with producing oil in the harsh North Sea environment quickly led to the development of a competitive European petroleum equipment industry. Although much of the technology originated in the United States—particularly from the experience of offshore development and production in the Gulf of Mexico—European companies thoroughly integrated US technology into their own manufacturing operations. []

The Industrialized Countries

The *United Kingdom* and *Norway*—the two major producing countries in the North Sea—both developed extensive offshore equipment supply industries during the 1970s (appendix A). The British consistently encouraged multinationals to establish manufacturing facilities in the United Kingdom to supply the North Sea offshore business. Until recently, the British were more concerned with developing their hydrocarbon resources with the best available technology and creating employment in Britain than developing indigenous UK companies and UK technology. As a result, foreign companies—primarily US—operating in the United Kingdom make up a large segment of the British offshore supply industry. Oslo, on the other hand, has seen less need for rapid oil development and has concentrated on developing a competitive indigenous oil supply industry. As a result, Norway has emphasized the development of domestic capabilities through the commitment of foreign research and development (R&D) funds to Norwegian companies (table 1). []

Other European governments have pushed development of indigenous equipment supply industries mainly for export. For more than 20 years, *France* has strongly supported an indigenous oil equipment industry believing that a competitive French industry would improve access to foreign oil resources and the security of its supply. According to an industry trade publication, the French have provided more incentive and financial support for the development of offshore

technology than any other government. French exports of oil and gas equipment and services—totaling \$6.6 billion in 1983—rank second worldwide after the United States and have been one of France's leading foreign exchange earners for several years. State interests played a prominent role in the development of the petroleum industry in *Italy* and the promotion of Italian companies to among the technological leaders in the world petroleum equipment industry. Much of Italy's technical expertise arises from large government R&D budgets that led to such projects as the Transmed gas pipeline from Algeria and frontier drilling activities in deep water. Other European countries including *West Germany*, *the Netherlands*, *Switzerland*, *Austria*, *Sweden*, and *Finland* also developed extensive petroleum equipment industries during the industry boom of the 1970s. []

West European multinational oil companies, such as Royal-Dutch Shell, British Petroleum, AGIP, Total, and Elf, have been instrumental in assisting the development of the European petroleum equipment industry. In particular, Elf and Total worked closely with French equipment companies to develop oil discoveries in the North Sea, West Africa, and other parts of the globe. Development of the Finnish industry, in contrast, was helped by its close trading relationship with the Soviet Union. Expert Finnish shipbuilding capabilities, augmented by US drilling equipment and technology, has increasingly been used by the Soviets in their work in the Arctic. []

Japan's dependence on petroleum imports led Tokyo to attach great importance to promoting foreign production of crude oil by Japanese companies. The formation of the Japan National Oil Corporation (JNOC) in 1967 to promote Japan's exploration and development programs helped stimulate development of the petroleum equipment business in Japan. The strongest force behind the growth of the Japanese equipment industry, however, has been the Japanese multinational companies, such as Mitsubishi, Mitsui, and Hitachi Zosen, and Japanese steel companies,

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Table 1
European Government Support to
Offshore Equipment Industries

Type of Policy	United Kingdom	France	Norway
Assisting early entry of firms into the industry	NEGL	Substantial	Slight (successful private firms)
State backing for long-term major project research and development	NEGL	Substantial	Increasing in recent years
National oil company purchasing	Slight	Major	Major
Full and fair opportunity for domestic supplier	Major	NA	Major
Open door to foreign firms	Major	Strong restrictions	Controlled joint ventures
Selective promotion of major firms	NEGL (except for platform construction yards)	Major	Significant

Source: *Oilman*, November 1983.

such as Nippon Steel, Nippon Kokan KK, and Kawasaki. Recognizing business opportunities in the petroleum construction industry during the 1970s, these companies began to develop the expertise and experience to compete globally with US suppliers, particularly in the offshore construction business. []

In *Canada*, many equipment supply companies are affiliates or subsidiaries of US corporations that have serviced the onshore Western Canadian market for many years. Canadian companies also began developing expertise in manufacturing equipment for Arctic oil production as exploration and development in northern Canada grew. []

The Developing Countries

Government action in many less developed, oil-producing countries has led to the creation of domestic equipment industries geared primarily to serving local markets. *Mexico*, which expropriated its petroleum industry from foreign operators a half century ago, is archetypical of this group. Technology licensing from US companies by equipment manufacturers in Mexico has been common for many years, and, increasingly driven by budgetary constraints as well, Mexico meets most of its domestic equipment needs except for some high-technology electronic and metallurgical equipment. Most major OPEC countries, including *Saudi Arabia* and *Indonesia*, also require

domestic participation in lower technology oil equipment manufacturing that is creating domestic oil production and transmission capabilities. More recent non-OPEC oil producers—such as *Brazil* and *India*—have also promoted development of domestic petroleum equipment industries with considerable success, although they do not yet have the range of equipment or technologies available elsewhere. For instance, 90 percent of Brazil's oil equipment purchases are from domestic suppliers, according to Embassy reporting. []

Several non-oil-producing, newly industrialized countries led by *Singapore* and *South Korea* have achieved a major role in the petroleum equipment export industry. Singapore has long been a manufacturing and supply center for US, European, and Japanese multinational equipment and service companies. Foreign subsidiaries and joint ventures located there provide essentially the full range of equipment needed for both onshore and offshore operations. About 450 oil equipment companies operate in Singapore, of which 70 percent are US subsidiaries, according to the US Embassy there. Indigenous Singapore companies have developed the capability to design and

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construct large offshore facilities. South Korea has emerged as a major supplier of steel-related equipment for the petroleum industry. Hyundai Heavy Industries and Daewoo both have been building state-of-the-art offshore rigs, recently winning some of the largest and most technologically demanding rig building construction contracts ever. For instance, Daewoo recently signed a \$425 million contract with a US company to construct six deepwater, harsh environment semisubmersible drilling rigs. Korea has also gained experience in offshore oil and gas drilling and, according to one industry report, plans to enter the US offshore drilling market. []

Today, the internationalization of the petroleum equipment business has reached almost every phase of the industry. Engineering and construction firms handling the development of petroleum projects receive qualified bids from all parts of the globe. Often equipment for each element of a project is from a different country and large projects have a mix of American, European, and Asian firms supplying goods and services. International joint ventures and consortiums composed of firms from different countries—each contributing its particular specialties—are widespread:

- Japanese and Korean firms are constructing offshore drilling platforms for development of deep offshore reserves and Arctic reserves.
- French, Italian, British, and Korean companies are developing Libya's offshore Bouri field.
- French, German, British, Finnish, and Canadian firms are selling advanced oil and gas equipment to the USSR.
- Ongoing Iraqi pipeline projects involve a mix of French, Italian, Japanese, and US engineering, construction, and equipment firms.
- Japanese, West German, British, French, and US companies are participating jointly in China's newly opened petroleum sector. []

Foreign Availability

We believe US equipment manufacturers possess state-of-the-art technology for all aspects of petroleum exploration, drilling, production, and pipelining. No other country has the breadth of technological

capability and manufacturing capacity, in our judgment. US manufacturers, in particular, can respond rapidly and economically to requirements for special components capable of satisfying any unusual specifications. Additionally, US oilfield products have established strong reputations for reliability and durability, offering foreign customers greater assurance than newer foreign equipment manufacturers that the products will be cost effective. []

Our analysis indicates, however, that several foreign sources now exist for the majority of equipment manufactured in the United States. Except perhaps for the most sophisticated computer hardware, products embodying advanced microelectronics, and for highly specialized production gear involving advanced metallurgy and high-pressure elastomer seals, we believe the United States has lost its sole-source supplier status in petroleum-related equipment. Some high-technology equipment, particularly that used in high-pressure, high-temperature corrosive oil and gas production, can be procured abroad only from US subsidiaries. We believe the reason that foreign competition is absent in most of these specialized petroleum equipment categories is not a lack of technical capability but an assessment of market profitability by potential competitors. Foreign companies often cannot economically undertake the expensive process of starting up production and competing with the US companies without significant government support. Nonetheless, the extent of foreign equipment availability covers the gamut of applications, including geophysical exploration, drilling, production, transmission, control, and engineering and management services (chart [])

Geophysical Equipment

Some of the most sophisticated petroleum industry technology is found in geophysical exploration equipment. Most notably, the complex process of geophysical surveys frequently uses advanced devices for acoustical, magnetic, and ultrasonic sensing, combined with state-of-the-art computer processing technology. According to an industry estimate, the oil

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Relative Strength of Major Petroleum Equipment Manufacturing Countries

● State of the art

⊗ Competitive

⊙ Developing capability

● Inferior

○ No demonstrated capability

	United States	Canada ^a	France	West Germany	Italy	Norway	Japan	United Kingdom ^a
Geophysical Equipment								
Onshore	●	⊙	●	⊙	○	○	⊙	⊙
Offshore	●	⊙	●	⊙	○	●	⊙	●
Drilling Equipment								
Rigs/derrick (onshore)	●	●	⊙	⊙	⊙	○	⊙	○
Drill bits	●	●	⊙	⊙	○	○	⊙	⊙
Drill pipe	●	●	●	●	●	○	●	●
Logging equipment	●	⊙	●	⊙	○	○	○	⊙
Production Equipment								
High-pressure wellheads and blowout preventors	●	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Downhole well equipment	●	●	⊙	○	○	○	○	⊙
Casing and tubing	●	●	●	●	●	○	●	●
Submersible pumps	●	○	⊙	⊙	○	○	○	⊙
Remote control systems	●	●	●	⊙	⊙	⊙	⊙	●
Offshore Equipment								
Drilling and production platforms	●	⊙	●	⊙	●	●	●	●
Riser and motion compensation systems	●	⊙	●	⊙	⊙	●	⊙	⊙
Dynamic positioning system	●	⊙	●	⊙	⊙	●	⊙	●
Heavy lift equipment	●	○	⊙	⊙	●	○	⊙	⊙
Remotely operated vehicles	●	●	●	⊙	⊙	⊙	⊙	●
Transmission Equipment								
Large pipelayers	●	○	○	○	⊙	○	●	○
Large-diameter pipe	⊙	⊙	⊙	●	●	○	●	●
Gas turbines/compressors	●	⊙	⊙	⊙	●	⊙	⊙	●
Pipe inspection equipment	●	●	○	○	○	○	⊙	●
Control and data acquisition systems	●	⊙	●	●	●	⊙	⊙	●
Engineering and Project Management Services								
Onshore	●	⊙	⊙	⊙	⊙	○	⊙	⊙
Offshore	●	⊙	⊙	⊙	⊙	⊙	⊙	●

^a Dominated by United States subsidiaries.

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Military Applications of Petroleum Equipment

Although the vast majority of petroleum equipment has no direct military application, several groups of high-technology equipment—primarily incorporating advanced electronics or metallurgy—can be readily diverted to important military applications. Trade in these items with Soviet Bloc countries has been effectively controlled for the most part through COCOM restrictions adopted in the last few years. At present, Sweden and Finland are believed to be the only non-COCOM countries capable of manufacturing some of this military-related equipment, but the situation could change as advanced petroleum technology becomes more broadly dispersed. []

The greatest potential for diversion of Western petroleum technology and equipment exists in the sale of state-of-the-art computer and other electronic equipment. Powerful computers with array processors for geophysical processing and superminicomputers used for field geophysical work and petroleum network operations control can also be directly employed in antisubmarine warfare, ballistic missileery, and tactical military operations. Advanced geophysical devices for magnetic, acoustic, and ultrasonic sensing have similar military and naval applications. Advanced satellite navigation equipment and ship motion compensation and dynamic positioning systems

for offshore petroleum operations could be used by naval vessels for similar purposes. Remotely Operated Vehicles (ROV), submersibles designed to work on subsea petroleum structures, have alternative naval application in mine neutralization and object search and retrieval. []

The technology embodied in corrosion-resistant production equipment and in equipment for high-pressure, high-temperature operating conditions is also applicable to conventional and nuclear weapons development, naval nuclear propulsion systems, and rocket and jet engines. To apply this technology to military purposes would require reversing the engineering of the equipment to understand its qualities and means of manufacture. Acquisition of advanced metallurgical manufacturing technology and equipment used to make petroleum gear could be diverted directly to these military applications. For instance, the metallurgy for making drill bits and tungsten-carbide inserts and high-performance turbine rotor blades have the potential to help military/defense research and development. []

industry is spending \$2.5 billion a year to gather seismic records and another \$1 billion to process and interpret them using large-array processors that tackle repetitive calculations and do three-dimensional analysis.

suppliers based on the technological strength of companies such as Sercel, Compagnie Geophysical Generale (CGG), and Thomson-CSF. Additionally, Geophysical Company (GECO) of Norway and Prakla-Seismos of West Germany have growing or competitive capabilities in geophysical surveying, oceanographic research, and three-dimensional seismic profiling. Although the market for array processor-equipped superminicomputers and advanced computer software for geophysical analysis is

France probably has the most sophisticated capability in petroleum geophysical exploration among foreign

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dominated by US suppliers, [] foreign survey companies typically modify the acquired US software for use on their computers and make it part of their proprietary service package. Almost all foreign equipment will produce adequate results and is usually less expensive and more readily available, although US geophysical equipment generally meets higher technical standards for sensing and data processing than foreign equipment. []

Drilling Equipment

Foreign availability of most drilling equipment has increased dramatically in the last 10 years. Virtually all standard drilling equipment—including the major elements of the drill rig, such as the *derrick, draw-works, drillstring, kellys, drill collar, stabilizers, and tool joints*—is now available from numerous manufacturers throughout the world. Although US manufacturers controlled about 95 percent of the foreign market 10 years ago, foreign manufacturers now supply about half of foreign drilling equipment, []

As a result of their North Sea experience, French, Italian, and West German companies now have sophisticated drilling equipment technology and manufacturing capabilities, and Norwegian companies, supported by the government, are committed to becoming leaders in international drilling technology, [] In each of these countries, national oil companies now rely primarily on domestic manufacturers for drilling equipment. Outside of Western Europe, Canadian companies have significant onshore drilling experience, and the Japanese have also begun to manufacture drilling equipment using US licenses. []

Foreign companies are also making great strides in the use of electronics to improve drilling efficiency. Important advancements in *wire line logging tools* include development of multiple downhole sensors that transmit data to the surface and wellside computers. *Measurement-while-drilling (MWD) systems*, which monitor the direction of drilling, have advanced rapidly as have *vertical seismic profiling (VSP)*, which allows the operator to see ahead of the drill bit. Besides US companies, French firms, such as Schlumberger and SMF International, produce electronic

drilling equipment, and Norway has targeted logging technology and equipment for research and development. []

Diamond and carbide drill bits used in exploratory and production drilling worldwide are readily available from a large number of foreign manufacturers and US-licensed companies abroad. Although foreign drill bits probably are inferior in metallurgical quality, [] foreign manufactured products of acceptable quality are being purchased primarily because of price and financing advantages offered by non-US suppliers. Growing foreign competitors to US firms include Sandvik of Sweden and Tsukamoto Seike of Japan. Developing countries, such as India and Pakistan, are also starting to produce equipment for domestic use. An important advance in bit technology has been the development of *polycrystalline diamond (PCD) bits* that lower drilling costs in many applications. Although developed in the United States, Sandvik of Sweden, the world's largest maker of cemented carbide and specialty tools, has emerged as a leader in the PCD bit field. []

Wellhead Equipment

Onshore and offshore wellhead equipment—*Christmas trees, blowout preventors (BOPs)* and associated *control systems*—are now produced by many manufacturers throughout the world, although the non-Communist world market is dominated by firms with access to US technology. The key technical difference among manufacturers is their ability to produce equipment able to withstand extremely high-pressure—10,000 to 15,000 psi—environments. [] US firms and their foreign subsidiaries control the small, but growing high-pressure wellhead market, but a number of foreign countries, led by the Norwegians, French, British, and Italians, are moving into the high-pressure offshore wellhead field. []

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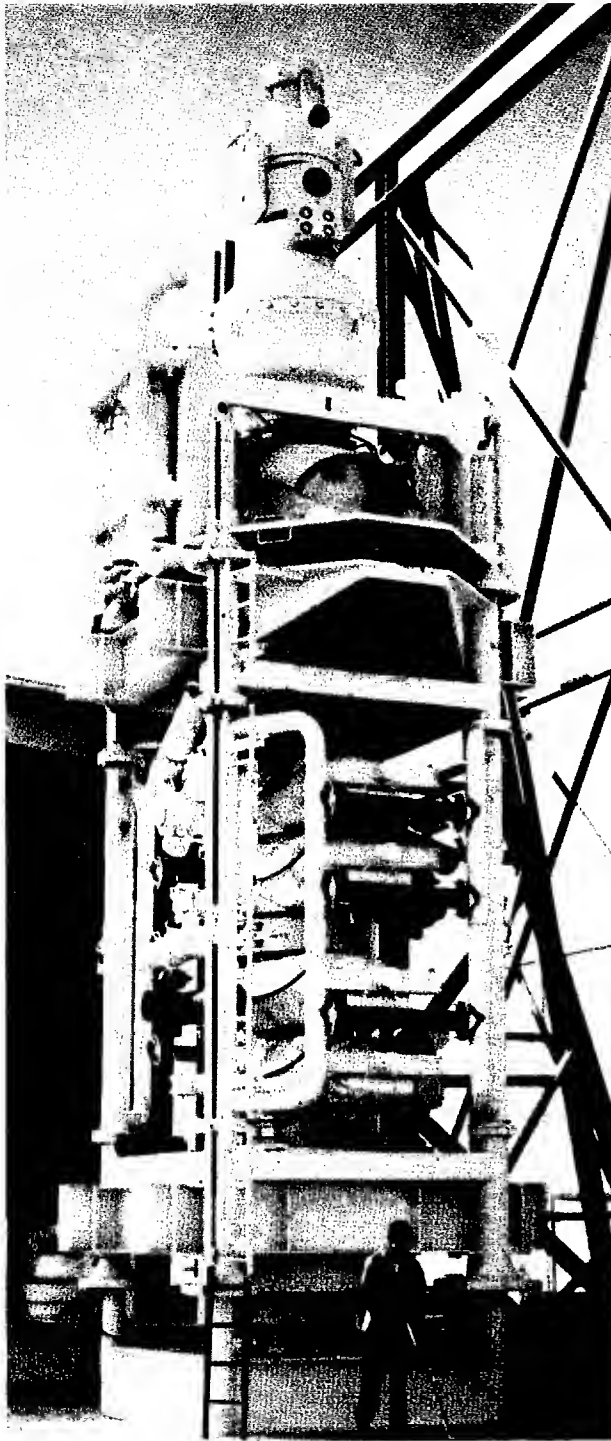
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15,000 psi subsea blowout preventor. [redacted]

Completion and Lift Equipment

A few US oilfield equipment companies and their foreign subsidiaries dominate the international market for downhole completion and artificial lift equipment [redacted]. Major completion equipment components include *float shoes* and *centralizers* for well cementing, specialized *well service tools*, equipment such as *packers* and *flow control equipment* for production control, *wire line equipment* for removing components from a well, and *well safety valves*. Like the well completion equipment market, a few US companies and their foreign subsidiaries control world production of *high-capacity, submersible electric pumps* and *gas lift recovery system valves*. [redacted] foreign manufacturers cannot seriously compete unless they are able to penetrate the US market where most of the non-Communist world's wells are. The relatively low number of well completions and artificial lift programs outside the United States and strong reputation of US suppliers have provided little opportunity for development of foreign competition so far. Still, some foreign companies including Flopetrol-Johnson of France, Site Oil of Canada, and Industrialexport of Romania sell limited completion and lift product lines, but they do not compete in the high-pressure, high-temperature, corrosive environment well market.

[redacted] most downhole completion and artificial lift equipment does not involve high technology, and the decisive factor for foreign manufacturers to enter the field would be profit potential, which could rise sharply if US manufacturers were forced out of markets because of exceptionally high prices or trade restrictions. [redacted]

Offshore Equipment

The tremendous growth of the offshore industry has led to a diffusion of offshore technology and equipment manufacturing capability to many countries throughout the world, including Great Britain, Norway, the Netherlands, France, Finland, Italy, Japan, Brazil, and Japan. Numerous foreign engineering and

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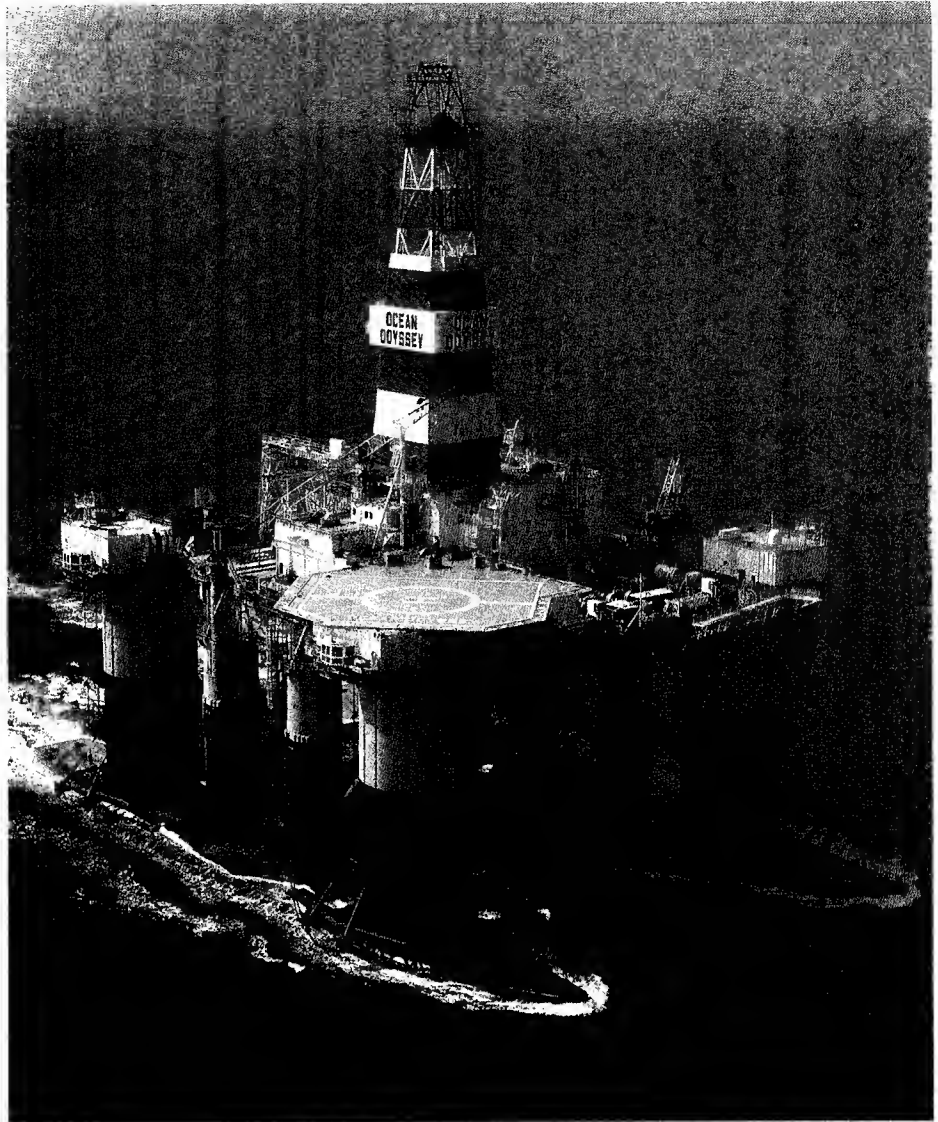
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Ocean Odyssey. Japanese-built, semisubmersible drilling rig.



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construction companies in Western Europe and East Asia have the ability to design and construct the largest and most advanced offshore drilling and production platforms in use today. Moreover, in light of the expected growth of offshore production and the sizable capital investment it requires, many foreign governments, including the United Kingdom, Norway, France, and Italy, are trying to establish their countries as leaders in offshore production technology and manufacturing capability.

Subsea technology and equipment is perhaps the major area of the offshore industry that was an exclusive domain of US companies, but is no longer. Although subsea technology originated in the United States, many US companies have manufacturing facilities in Europe, South America, and East Asia, and licensing agreements have been made with numerous major foreign firms. Although US firms still have the most experience in engineering, manufacturing, and installation of subsea equipment, British,

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French, Norwegian, and more recently Brazilian companies have entered the subsea market with competitive technology. []

Technology and equipment to exploit offshore Arctic resources are currently under development in a number of advanced countries that are vying for the potentially large Arctic offshore market. Finland produces 60 percent of the world's icebreakers, needed to support Arctic oil operations, and is an important supplier of Arctic offshore drilling rigs and platforms as well. Japanese companies have recently fabricated large offshore drilling platforms for use in the Beaufort Sea offshore northern Alaska and Canada. []

The offshore industry requires a large variety of other specialized equipment and technologies as well, most of it available abroad:

- *Remotely Operated Vehicles (ROVs)* have become essential in deepwater production to service subsea equipment, which is uneconomical to reach by manned systems. France, Canada, Norway, Sweden, the United Kingdom, and Japan are all active in ROV development.
- Companies in France, the Netherlands, the United Kingdom, and Finland manufacture *dynamic positioning systems* and *motion compensation systems* using sophisticated onboard computers to keep drill ships stable and in position in deep water.
- Dutch and Italian companies are world leaders in the design of *heavy lift barges*, and Japanese companies, such as Sumitomo and Mitsui, have built the majority of these massive vessels.
- Saipem of Italy is a world leader in *deep sea pipeline construction* having constructed pipelines in the Norwegian trench and in the Mediterranean at depths up to 600 meters. France's ETPM is also expert in underwater pipeline construction. []

Transmission and Control Equipment

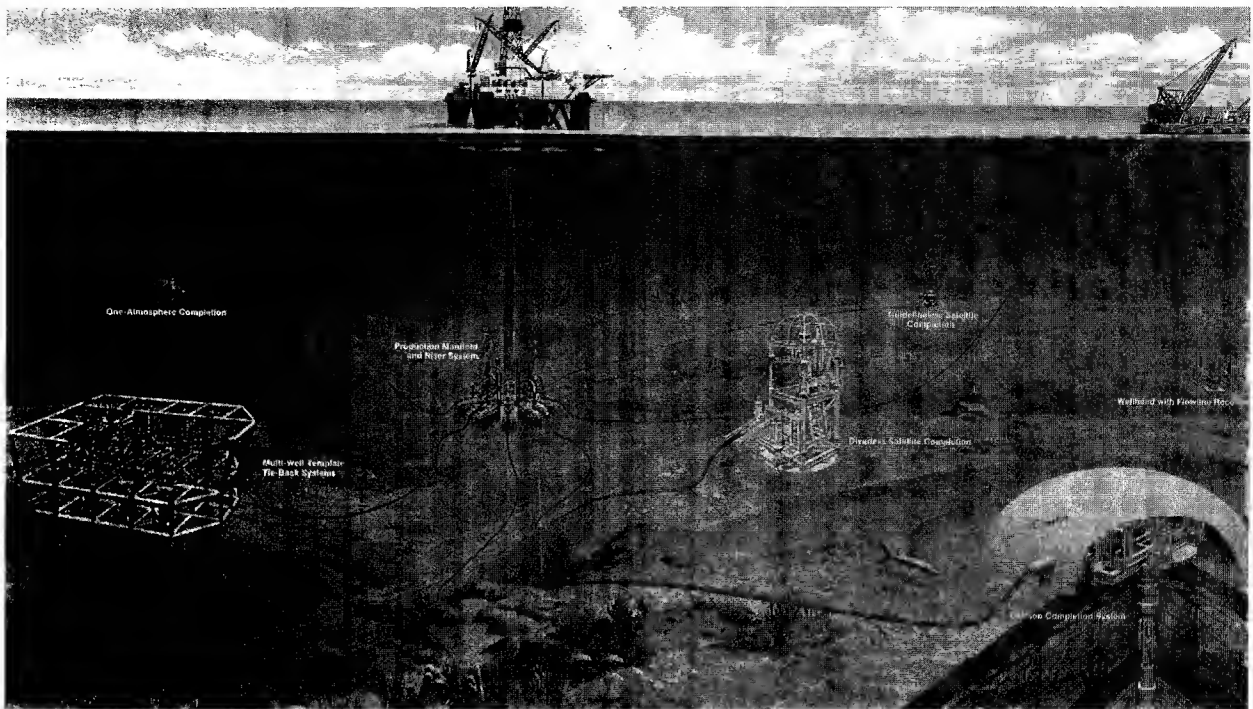
Virtually all technology and equipment involved in building and operating crude oil and natural gas pipelines are widely available abroad and, in some

Subsea Oil Systems

Subsea oil systems are characterized by the use of a nearby fixed platform as field center, with subsea completed wells—single satellite wells or template wells—connected to the platform. The fixed platform provides all major functions and support, such as manifolding, power supply, monitoring, control, and processing. More advanced subsea technology and concepts are being developed that use a distant platform as a field center with a complex network of subsea facilities that are installed and maintained remotely. Subsea oil systems technology has largely been derived from advances in the aerospace, nuclear power, submarine, robotics, and automation industries. []

cases, foreign manufacturers have the most advanced technology and experience:

- Although many foreign steel mills produce *line pipe* up to 48 inches in diameter, only a few countries including West Germany, Italy, and Japan produce 56-inch-diameter pipe. In fact, 56-inch line pipe is one of the few types of petroleum equipment that is not produced in the United States.
- *Gas turbines* in all sizes are available from a number of foreign suppliers, including Nuovo Pignone of Italy, Hispano-Suiza of France, A. S. Kongsberg of Norway, Sulzer and Brown Boveri Company (BBC) of Switzerland, and Hitachi of Japan. []
- *High-capacity compressors* are produced by many foreign manufacturers, including competitive models produced by Nuovo Pignone of Italy and Thomassen of the Netherlands. The market for *small gas compressors* ranging in output from 10 to 800 horsepower (HP) is controlled by a few foreign companies, including Atlas Copco of Sweden and Demag of West Germany.



Equipment used in subsea production.

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- *Pipeline instrumentation and control equipment*—such as *supervisory control and data acquisition (SCADA) systems*—are available from suppliers in France, the United Kingdom, West Germany, and Japan.
- Although US companies still dominate the *pipeline inspection equipment* market, British Gas Corporation is considered a particularly strong potential challenger offering state-of-the-art equipment with highly sophisticated computer instrumentation incorporated in the inspection tool.
- Large, specialized *onshore pipeline construction equipment*, such as *sideboom tractors*, can only be purchased from a few foreign countries. A US firm and Komatsu of Japan control the world's supply of large *pipelaying vehicles*.

Engineering and Project Management Services

Engineering and project management services are essential elements of virtually all energy development projects. Although US firms are still recognized as the most skilled project managers, especially for

difficult projects that require high productivity and completion in a minimum of time, foreign companies—such as Technip of France, Snamprogetti and Saipem of Italy, Davy McKee and John Brown of the United Kingdom, and the Japanese companies Mitsubishi and Mitsui—are stiff competitors. In Southeast Asia, Japanese engineering is predominant but is being challenged by competition from Korean firms. Major West European firms are active in all other areas of the non-Communist world. With the increasingly fierce competition for major projects,

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a trend is developing in which US firms do the front-end engineering and design work and overall project management, but foreign companies receive the contracts for detailed engineering, procurement, and construction. This enables the client to combine the best design and management skills from the United States with less expensive foreign construction—the major project expense.

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Arctic Offshore Production

Offshore exploration in the Beaufort Sea has been under way for 10 years, and a variety of techniques for exploratory drilling in ice-infested waters have been pioneered. Conventional drill ships have been used during times of no ice or light ice, and icebreaking tugs have been used to allow drill ships to remain on station well into the winter. At protected sites where ice motions are small, artificially thickened ice platforms have been used successfully. By far the most commonly used method of providing a drilling platform has been the construction of artificial islands made with sediment dredged from the nearby sea floor or transported from shore. These islands have been built in water up to 19 meters. Steel and concrete refloatable, bottom-founded structures are also being developed.

Once oil or gas is found, exploration systems will be replaced with even larger production systems designed to last for roughly 20 years. Auxiliary systems, such as subsea pipelines and, in some cases, subsea production systems, will be required and will have to be protected from ice scour. Improved sensors, such as radar, acoustics, and optics for detecting ice threats against the production system, will be required. Tankers used in conjunction with icebreakers are possible alternative export systems to subsea pipelines. Huge submarines have also been considered as an export system.

New Market Factors

As the petroleum equipment industry became broadly internationalized in the early 1980s, it was hammered by a severe worldwide recession following the dramatic downturn in oil demand and the ensuing drop-off in oil prices. Global drilling expenditures outside the Soviet Bloc—an important indicator of the health of the petroleum equipment service industry—fell 35 percent in 1984 from its 1982 peak of \$70.2 billion. More than 81 percent of that drop—some \$19.8 billion—occurred in US drilling expenditures, the non-Communist world's largest market. Foreign markets suffered much less, experiencing a \$4.5 billion

cut—or an 18-percent reduction—in drilling expenditures although the level of drilling activity remained largely unchanged (table 2). The petroleum equipment industry recession abroad was a depression in the United States. Surplus manufacturing capacity developed in every segment of the service and supply industry worldwide. The severe competition for remaining markets led to the increasing prominence of low costs, concessionary financing, and special political relationships as the primary factors in determining which companies receive equipment and service contracts. We expect these factors to continue to dominate the international petroleum equipment market over the decade.

In their competition abroad with foreign manufacturers, US companies have been hit particularly hard during the recession by the strength of the dollar, traditionally higher labor costs, and older technology in some equipment manufacturing processes. As a result, some identical products cost far less to manufacture abroad than in the United States. For example, steel made in South Korea costs approximately one-third that made in the United States. Labor cost differentials are evident in the wages paid to oil industry welders.

Moreover, in a highly cost-conscious market, more subjective considerations of technical superiority and experience—areas of US strength—carry substantially less weight in investment decisions. That the US suffered as a result of these international competitive forces is reflected in the precipitous slide of US petroleum equipment exports from about \$11 billion in 1982 to about \$5 billion in 1984, according to official US trade statistics.

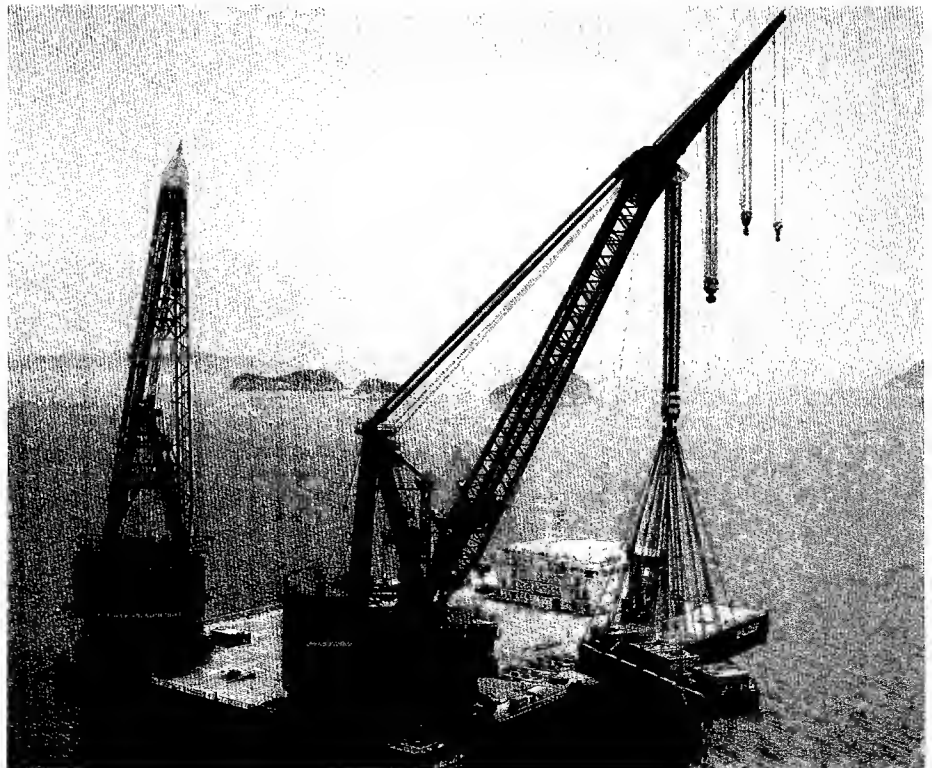
Intense competition has also increased the importance of favorable financing arrangements in winning competitive bids abroad, especially for major contracts. project financing dictates which companies receive business.

British-built remotely operated vehicle used for subsea repair and maintenance.



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Balder. Japanese-built, off-shore crane, 3,000-ton lifting capacity.



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Table 2
Non-Communist World Petroleum Industry
Drilling Expenditures

Billion US \$

	1982		1984		1990		Average Annual Growth Rate, 1985-90 ^a	
	Onshore	Offshore	Onshore	Offshore	Onshore	Offshore	Onshore	Offshore
Total	45.5	24.6	25.4	20.4	47.8	36.3	11.1	10.1
United States	37.7	6.8	19.5	5.2	34.5	8.1	10.0	7.7
Canada	2.2	1.4	1.6	1.3	4.4	4.1	18.4	21.1
Western Europe	0.4	7.1	0.3	5.2	0.7	9.2	15.2	10.0
Latin America	2.3	2.7	1.4	2.3	3.0	4.0	13.5	9.7
Middle East	1.0	1.9	0.8	2.0	1.8	3.0	14.5	7.0
Africa	0.9	1.9	0.8	1.8	1.6	3.1	12.2	9.5
East Asia	1.0	2.8	1.0	2.6	1.8	4.8	10.3	10.8

^a Estimated.

Foreign manufacturers can frequently offer more attractive financing because of government support and greater flexibility to engage in barter deals. For instance, concessionary lending terms by the Export-Import Bank of Japan are helping Japanese oil development firms working offshore in Southeast Asia. According to an authoritative oil industry publication, the Tokyo bank sets its loan rate for development of overseas resources for import into Japan between 6 and 7 percent, appreciably lower than normal international commercial lending rates. Multi-national trading companies from oil-importing countries, such as South Korea and Japan, have become particularly adept at trading services for oil exports from countries with low foreign currency reserves or soft currency. South Korean companies are lifting about 50,000 barrels per day (b/d) from Libya in trade for a variety of engineering services. European governments, particularly in France, West Germany, and the United Kingdom, also have government-backed financing programs and encourage barter arrangements to support petroleum equipment exports. The United Kingdom's Export Credits Guarantee Department (ECGD) is often cited by industry sources as improving the competitive position of British equipment exporters.

Special political relationships—both positive and negative—have also affected the ability of Western equipment suppliers to market their products. In many cases, they determine which country's companies may even be considered for a contract. Most important is the tendency—dictated by tradition and local content law—for equipment purchasers to favor domestic suppliers when they are available. As the domestic equipment industries in new oil production countries grow and become able to provide better products, foreign suppliers are increasingly excluded from the market. This trend has been noticeable in Brazil and may soon be the case in India. Italy's long relationship with Libya has provided important advantages in competing for oil service and construction work there. Business trade-offs involved in such a relationship led AGIP to agree to relatively unfavorable terms to develop Libya's offshore Bouri field in large part because most of the construction work will also be handled by Italian firms. The US industry's relationship with Saudi Arabia and French involvement in Algeria are somewhat similar in giving preferential treatment to contractors.

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Adversarial political relationships and government policies have a more immediate impact on the equipment industry. Tehran's aversion to French or US equipment and service companies and Iraq's parallel reluctance to deal with Japanese equipment suppliers restrict business alternatives, as do US restrictions on equipment sales to the Soviet Union and Libya. On balance, these political relationships appear to have adversely affected the ability of the US petroleum industry to compete abroad in recent years and have expanded market and technological opportunities for foreign suppliers. []

Market Trends and Technology Development

We expect the international petroleum equipment market to continue its steady recovery from its 1983 bottom but do not expect the market to reach its 1982 peak again until late this decade, and then only on a current dollar basis. Such a recovery is predicated on the absence of an oil price collapse that remains a significant risk in the next few years. A less likely risk—the major disruption of international oil trade by war or political instability in major producing countries—could drive the market up more quickly than expected in response to escalating oil prices and the possible need for emergency restoration. With most forecasters expecting non-Communist world oil demand to increase only modestly—average annual growth between 0.5 and 2 percent over the balance of the decade—we believe demand for equipment and services will probably grow an average of 10 to 11 percent per year on a current basis as investors recover from the precipitous drop of 1983 and anticipate significant real oil price increases in the 1990s. []

The growth of industry investment and expenditures will be uneven in its strength and geographical distribution, however:

- The US onshore oil industry—which has traditionally accounted for almost all oil industry investment—will be the slowest growing regional onshore market over the balance of the decade. Still, we expect the United States to constitute more than half of the world's petroleum equipment market into the 1990s.

- Among other onshore markets, those with the largest accessible potential petroleum resources—the Middle East and Latin America—will probably be the focal point of exploration, development, and production activities.
- Canada, starting from a small base, will be the fastest growing national equipment market over the balance of the decade as it moves to develop its petroleum finds in the far north.
- Continued development of the North Sea will make it the largest offshore market during the 1980s, but growth rates will slow from peaks reached in the late 1970s. []

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The dramatic shift in the international petroleum equipment industry to a weakened and highly competitive market in which the United States is the major, but not uncontested, force is likely to continue. We believe lower profitability and increased competitiveness will probably mean continuing corporate consolidations among equipment companies in the industrialized countries, especially in the United States, France, and the United Kingdom. Moreover, increasingly restrictive local content laws in oil-producing countries is likely to force further industry underutilization, particularly at the low-technology fabrication end of the petroleum equipment market. []

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Equipment development efforts will probably focus on new materials and designs that will lower drilling maintenance and service requirements and new production equipment for harsh environments—both onshore and offshore. The need to develop marginal offshore fields will lead to continued development of simple, cost-effective subsea completion gear. Oil companies will also be interested as always in any technology capable of reducing exploration and development costs—the major capital investment in any petroleum program. These developments will all take place in an industry that is in the midst of some fundamental market changes with broad implications for the future of the equipment industry. []

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The Offshore Industry

The most important shift in the petroleum equipment market is the greater role played by the offshore market since the 1983 recession. The fall in offshore investment in 1983 was much less than onshore because of the longer time horizon for investment payback and much larger sums needed to carry out a single project. As a result, onshore and offshore markets probably will grow at nearly the same rates through the 1980s, although the offshore market will be moving to new investment highs as the onshore market tries to return to its 1982 peak. The offshore market probably will become even more important in the 1990s, further stimulating the growth of foreign equipment suppliers. In particular, advanced companies in Western Europe and Japan and low cost equipment manufacturers in Asia should benefit from this trend. []

The focus of offshore investment activities through the balance of the 1980s will probably be in the already established petroleum provinces of the North Sea and the Gulf of Mexico with work in the new Canadian offshore fields showing the fastest growth. Efforts in the established petroleum provinces will focus on adding new productive capacity near existing fields and increasing the productivity of current operations. Total annual average spending on North Sea projects is projected at more than \$15 billion through 1990, according to recent industry studies, and we expect suppliers in the United Kingdom and Norway will receive most of the contracts for this development. Canadian activities will focus on developing the new resource base established off Newfoundland and Labrador with US and Canadian companies probably receiving most of this work (table 3). []

We believe countries with large reserves and surplus capacity, such as the Arab producers of the Persian Gulf, will maintain programs at low levels while other countries, such as Australia, Indonesia, India, Brazil, and several West African countries, will move aggressively to develop their offshore production potential. Competition for contracts in the Third World will be particularly intense, although most of the development in more advanced nations will be handled by local suppliers. We expect predrilling exploration to occur primarily in the Norwegian Sea and Canadian Arctic Ocean but do not foresee major capital investment in these regions until the next decade. []

Table 3
World Offshore Outlook:
The \$50 Billion Market

Billion US \$

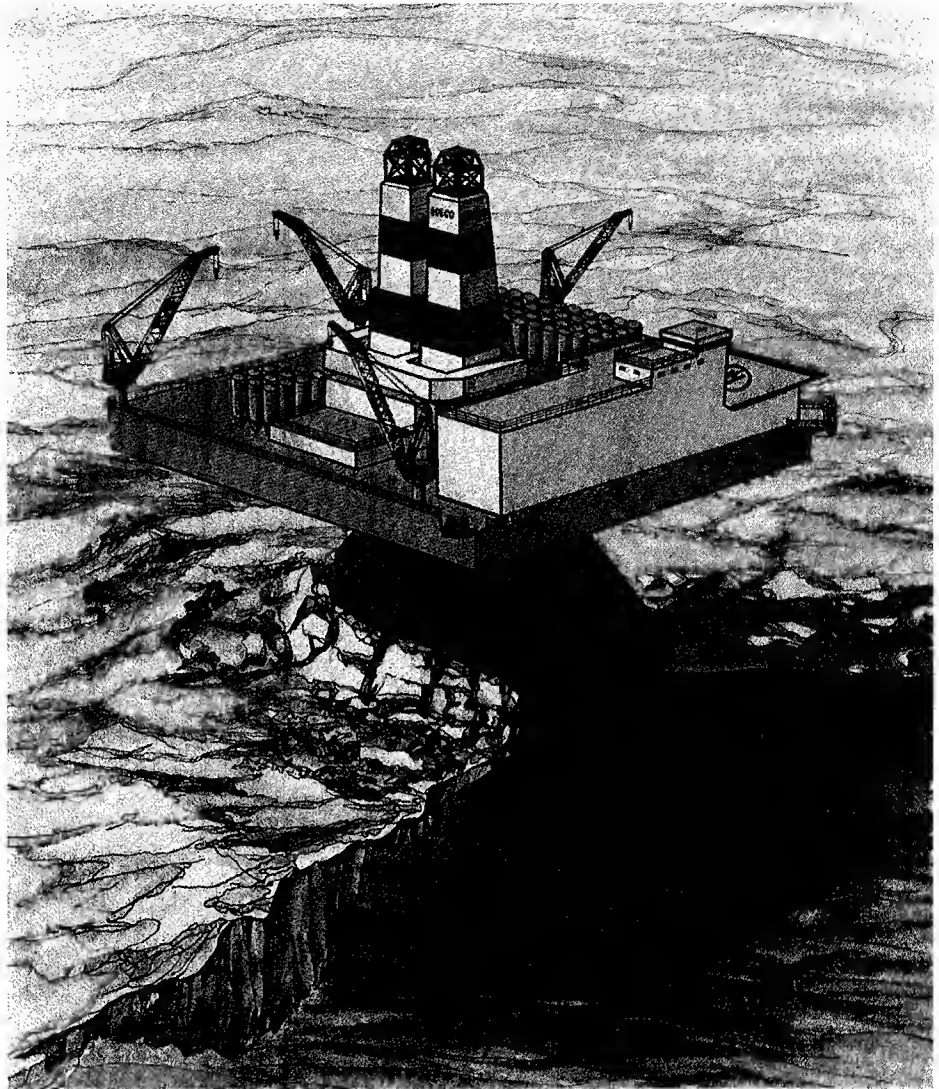
	1985	1986	1987	1988
By category				
Total	54.3	60.2	67.0	74.0
Development	23.2	26.2	29.9	34.4
Exploration and drilling	20.0	21.0	22.5	23.6
Operating costs	11.0	13.0	14.5	16.0
By region				
Total	54.3	60.2	67.0	74.0
North America	13.1	14.6	16.0	17.7
Central and South America	4.8	5.2	5.7	6.4
Europe	16.6	18.2	21.1	22.6
Middle East	5.3	5.7	6.0	6.4
East Asia	10.4	11.6	12.8	14.2
Africa	4.2	4.8	5.4	6.7

Source: *NOROIL*, April 1985.

As the offshore petroleum industry moves increasingly into deeper water and hostile climates, new techniques will be required in every phase of the industry. In light of the restraining influence of flat oil prices, however, most of the growth in the offshore industry this decade will emphasize improved performance and efficiency. [] We would expect the greatest technological innovation to occur in geophysical equipment and possibly exploration drilling techniques as the search for new oil moves into very deep water—over 400 meters—and Arctic environments. We also expect to see greater use of subsea production systems that will make the development of previously marginal oilfields economical and enable operators to push into still deeper waters, avoiding the dangers of rough or icy surface conditions. []

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*Japanese/American design for
an all-season Arctic mobile
drilling platform.*



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Oil operations will also increasingly use computer technology. Software firms in Europe and the United States are already offering programs for well planning, log analysis, casing, tubing and drill string design, blowout controls, and directional drilling. Computers are being used to monitor the performance of equipment and to search for failure and dangers. Computer-aided design (CAD) systems are playing a major role in producing new floating structures expected to replace traditional fixed platforms for development of new deepwater finds. By the late 1990s major technological and engineering breakthroughs will probably be much more critical in

developing offshore capacity to meet growing demand and possibly declining onshore oil production (table 4).

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The Onshore Industry

Most onshore expenditures in the non-Communist world will continue to be made in the United States. Major investments will be made both in finding new oil and upgrading oil recovery from existing fields,

Table 4
Current and Future Role of Electronics in the Oil Industry

Function	Current Technology	Future Technology
Drilling	MWD and rig floor sensors linked to computer functions provide improved drilling efficiency.	3-D holographic images to observe drilling progress and the formation penetration. Robotic controls of drilling operation.
Production—offshore	All production, processing, and alarm inspection systems are automated control centers.	Unmanned platform complexes to be operated onshore.
Seismic	Ability to transmit and correct data on location. Satellite telemetry can transmit real-time data.	Following real-time interpretation, detailed seismic survey will commence immediately.
Design	Computerized calculation and graphics enable engineers to design on a video terminal.	Software will receive environmental, production input and produce a completed design electronically.
Construction	Computer-aided manufacturing.	Computerization and robotics will provide fabrication of basic and even customized structural elements.
Installation—offshore	Placement of mobile and fixed structures are conducted hypothetically on computer graphics.	Advanced modeling of mating, towing, and installation critical for deepwater, hostile environment.
Underwater	Remote control, TV manipulators, microprocessors.	All underwater operations will be conducted by remote control and 3-D observation, assisted by artificial intelligence.
Transportation pipelines	Widespread use of SCADA for monitoring and control.	Increased technical sophistication of systems.

Source: *Offshore*, October 1984.

especially in Alaska. Oilmen expect that Canada and Latin America will be the primary areas of new foreign onshore drilling. Mexico, Venezuela, and Colombia all have active onshore programs under way. Mexico and Venezuela probably will continue their efforts to replace onshore oil reserves and maintain productive capacity. Equipment markets elsewhere will be closely linked to the local desire for petroleum self-sufficiency or exports, domestic petroleum prospects, and political stability:

- Iran and Sudan, among others, are not likely to attract major new investments despite their petroleum potential if more stable business environments do not develop.
- Yemen Arab Republic (North Yemen) and Iraq, in contrast, could be growing equipment markets.
- Major oil exporters with limited onshore reserves, such as Nigeria and Indonesia, are likely to maintain programs to ensure reserve and productive capacity stability.

Onshore petroleum programs, especially in the dominant US market, are moving into deeper structures with higher pressures and often extremely corrosive petroleum. These conditions require new corrosion resistant materials in drill pipes and casings such as chromium steel and nickel alloys. Among the most important new drilling developments likely to see broad use in the next few years for both onshore and offshore operations is MWD technology. MWD saves drilling time and averts downhole accidents by providing operators immediate information on downhole activity and environment through sensors or recorders near the drill bit. Downhole motors and turbodrills are being used in many straight-hole applications because their increased reliability and higher torque capability permit faster—and ultimately less expensive—drilling. As with offshore activities, the use of

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computers for monitoring and control of production operations is expected to grow tremendously. SCADA systems have become widespread in production, processing, and pipeline operations, and their use will continue to increase in all phases of facility operations. []

The USSR and China—The Special Cases

Ambitious energy goals in both the USSR and China could mean a major expansion of Western business opportunities well into the 1990s. Moscow, with the need to defer or prevent substantial oil production declines, faces serious technical problems in maintaining production in Western Siberia, developing reserves in Central Asia, and exploring the petroleum potential of the offshore Arctic regions. Beijing will need massive Western assistance to reach its goal to double oil production by the end of the century through a strategy of maintaining its mature onshore fields, developing its offshore potential, and beginning the search for oil in western China. Although these national markets will remain relatively small—annual average of less than \$1 billion each in Western sales—in the global petroleum market context, West European and Japanese companies are gearing up for them. Companies who enter these markets early could be in a better position for larger programs in the 1990s. []

Soviet interest in Western technology will probably increase as exploration and development shift to deeper and more complex onshore and offshore deposits, especially as exploitation of the deep sulfurous petroleum deposits in the Pre-Caspian Depression and Central Asia proceeds. In areas where hydrogen sulfide (H₂S) and carbon dioxide (CO₂) are present under high pressure and temperature conditions, the Soviets must acquire Western equipment including sour oil and gas manifold systems and blowout preventors, as well as controls for severe service and sour oil and gas processing and treating equipment. We also believe the Soviets will buy large quantities of basic oilfield equipment from the West including high-capacity submersible pumps, gas lift equipment, drill pipe tool joints, and drill bits. The Soviets are also likely to continue relying on Western sources for the bulk of their large diameter pipe and—despite claims to the contrary—large numbers of gas turbines. Although these needs are diverse, they represent only a modest part of a major undertaking the Soviets can largely execute themselves. []

The Soviet Union is also beginning to examine offshore Arctic areas as a possible major source of oil supplies and may put increasing emphasis on the exploration and development of the Barents and Kara Seas if onshore oil production continues to decline as we expect. By 1990 Moscow will probably add nine drilling rigs to the three already operating in the Barents and may ultimately spend nearly \$8 billion for Barents Sea petroleum development. []

[] Because of the numerous technical challenges in exploiting offshore Arctic petroleum resources, we believe the pace of Soviet exploration and development will depend on Moscow's willingness to permit a major role for Western firms in manning and managing operations and possibly on the availability of Western financing. []

In contrast to the Soviet Union, China is actively pursuing Western technology and equipment purchases and licensing arrangements in its quest to double crude oil production to 4 million b/d by 2000. Numerous Western and Asian companies have signed joint-venture agreements with the Chinese in areas ranging from seismic equipment to gas turbine manufacturing. In these agreements, the foreign partner usually provides the technology and training, and the Chinese partner supplies all materials and labor. Not unlike other new oil-producing LDCs, China's long-term aim is to develop its own petroleum technology and eventually export equipment and services. []

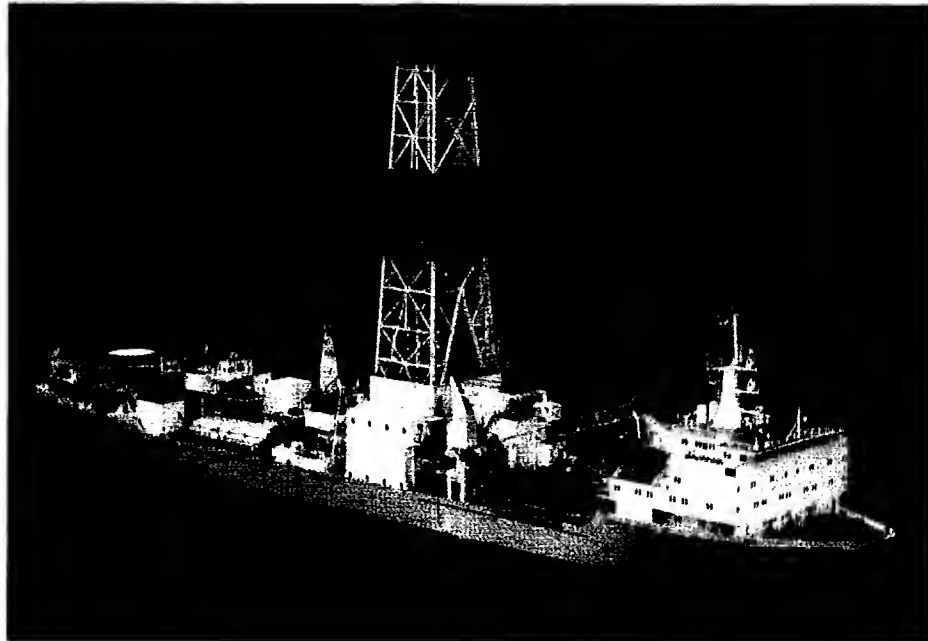
Beijing wants to increase development and recovery in existing onshore fields—including imports of well stimulation and enhanced recovery technology—to boost production with the least capital investment. []

The Chinese are particularly concerned about sustaining output through 1990 at the aging Daqing oilfield, which produces half of China's oil. As a result, China is looking for a full range of petroleum equipment, including drilling technology and equipment, production equipment—especially high-volume submersible []

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Victor Muravlenko. Finnish-built, dynamically positioned drill ship.



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Soviet-commissioned jack-up drilling rig under construction in Finland.



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electric pumps, and oil and gas separation and dehydrating facilities. In addition, China needs advanced seismic and geophysical equipment and services to explore for petroleum in the isolated Western desert.

China's offshore equipment needs are currently centered on exploration and drilling-related equipment. Offshore drilling more than doubled in 1984 over 1983 to a total of 45 exploratory wells and 30 development wells. Investment in offshore exploration jumped from about \$100 million in 1981 to \$600-700 million in 1984. If commercial reserves are found, China will need the full range of offshore development and production equipment and services available in the West. The apparent lack of success in offshore exploration efforts so far has diminished the prospects of a major offshore production equipment market in China by 1990, however.

Outlook and Implications

We expect the international petroleum equipment industry to continue to evolve in a manner that erodes the dominance of US equipment manufacturers both in market share and technology leadership. West European, Japanese, and Korean equipment manufacturers are likely to be the prime beneficiaries of this shift, but protected oil-producing LDC markets in countries such as Brazil and India also will lead to a new competitive force at least locally. Foreign manufacturing cost and financing advantages—compounded by the current strength of the dollar—and the spread of US technology as well as the growth of foreign petroleum technologies are critical—and largely irreversible—factors in this process. Moreover, the slow shift of investment away from the historically massive US onshore market to foreign offshore markets will compound the problems of US manufacturers who have traditionally had a sizable home court advantage. US petroleum equipment suppliers are likely to expand their manufacturing capabilities abroad to remain competitive in foreign markets, continuing the downturn in US equipment exports.

Besides greater competition abroad, the internationalization process will lead to increasing penetration of the US petroleum equipment market—still the world's largest—at the lower end of the technology range. The markets for high-technology and specialized equipment for particularly demanding conditions and onshore drilling will still be dominated by US companies and their foreign subsidiaries by the 1990s, but we expect competition to increase from companies in Western Europe and Japan.

The internationalization of the petroleum equipment industry has severely reduced the effectiveness of US unilateral export controls and, in our judgment, may soon challenge the effectiveness of COCOM controls on key dual-use equipment. Countries seeking equipment covered by US unilateral export licensing controls, such as the Soviet Union and Libya, can procure comparable equipment in most cases from suppliers in Western Europe, Japan, and occasionally from newly industrialized countries, such as Brazil, Mexico, Singapore, and South Korea when they cannot acquire it indirectly from US manufacturers.

In the few cases where US sole-sourced items are unilaterally denied a foreign country, we believe foreign petroleum equipment manufacturers could produce acceptable substitutes in one to two years if the market size warranted. The knowledge to design and produce most petroleum equipment is widespread, and the delays in providing alternative equipment would largely be attributable to the time to install a suitable manufacturing capability. In major petroleum projects, a two-year leadtime in acquiring equipment is largely inconsequential in economic terms because long manufacturing and installation lead-times and a long productive life are normally expected for such equipment. Moreover, if foreign companies grab markets from US companies, the foreign manufacturers will be in a stronger position to develop better technology, manufacturing capability, and international credibility to compete in what most observers expect will be a larger global petroleum equipment market in the 1990s.

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Petroleum equipment trade with Communist countries—restricted by COCOM regulations when there is a clear military dual-use technology involved—could also soon be challenged by alternative supplies from non-COCOM countries. Advanced countries that are not COCOM members, such as Sweden and Finland, have sophisticated petroleum industries that can produce some equipment currently controlled by COCOM. Although suppliers in the non-COCOM, newly industrialized countries are not yet able to manufacture COCOM-controlled petroleum equipment, increasing local electronics manufacturing sophistication could give them such a capability in the future. This changing pattern of petroleum equipment technology availability indicates that multilateral cooperation beyond COCOM may soon be needed to prevent military-related technology embodied in petroleum gear—particularly sophisticated exploration sensing and processing equipment—from reaching Bloc countries. However, agreement to expand the control of sensitive oil and gas equipment sales beyond COCOM will be difficult because of intense competitive sales pressure and disinterest in the security implications of such sales.

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Despite the likely adverse trade consequences for the United States, the increased equipment manufacturing capacity in the non-Communist world—particularly in the oil production and transmission sectors—would permit quick expansion of production to replace damaged equipment if a major oil supply source were disrupted in the near future. The heightened competitiveness of the industry has also led to reduced oil exploration and development investment costs for oil-importing countries, providing an incentive for more exploration and an opportunity to reduce reliance on vulnerable foreign oil sources, such as those in the Persian Gulf. International technological competition may soon enable economically attractive exploration of oil in the most hostile environments and drilling conditions, provide a capability to handle highly pressurized and corrosive reservoirs, and recover additional reserves from fields now in decline. The current global competition in petroleum equipment markets is a strong inducement for innovation in petroleum equipment products and manufacturing techniques that is likely to be important in advancing petroleum production and reserves in the 1990s when most forecasters next anticipate a tight oil market.

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Appendix A

The Petroleum Equipment Industries of Key Foreign Countries

This appendix describes the equipment industries of major foreign petroleum equipment manufacturing countries and highlights government policy supporting the development of an indigenous equipment industry. Other types of government support such as R&D and export assistance in both major and minor oil-producing countries are also discussed. Areas of special manufacturing capability or technical expertise are noted for each country as are key companies that play an important international role. []

Finland

The Finnish petroleum equipment industry has an established reputation in the construction of specialized vessels and drilling rigs for the offshore industry. Finland is one of the leading suppliers of Arctic offshore drilling rigs. The Finnish shipbuilding industry uses the most advanced technology available, and its products are highly competitive in the world marketplace in spite of relatively modest government financial support by international standards. []

Finland exports more than 80 percent of its shipbuilding production and about 50 percent of its exports are to the Soviet Union. Wartsila currently has a contract with the USSR to build five construction crane vessels for offshore operations. Rauma-Repola has fabricated three advanced drillships for the Soviets and is currently constructing two jackups, all for Arctic operations. As of late 1983 the USSR had 22 vessels on order with Finnish yards, including three research vessels, four ocean tugs, two crane ships, four multi-purpose carriers, two barge carriers, and five other special-purpose vessels. []

Finland is making a concerted effort in applied ice research and icebreaking technology. A large test-cone-type platform has been built recently at Valmet's Helsinki shipyard for measuring forces of ice against a fenced structure. Research work on ice also is being carried out at Wartsila shipbuilding company, the world's leading supplier of icebreakers.

Wartsila is the only shipbuilding firm that has the ability to carry on basic and applied research, model testing, product development design, production, and full-scale testing. Additionally, the Finnish Government operates a technical research center for studies on ice mechanics, winter navigation, instrumentation and measuring systems in cold climates, and Arctic construction and marine technology. []

Besides shipbuilding, Finnish companies are preparing to supply a range of offshore equipment to the Soviet Union. As part of this effort, the Finnish shipbuilder Valmet has just signed an agreement with a major US company to apply its expertise gained in the North Sea and Arctic Canada to the production of jackets, decks, and topside modules—equipment that can be used in the Barents Sea. Helsinki recently signed a bilateral trade program to supply Moscow offshore technology through 1985. []

France

The French Government has actively supported the development of an indigenous French oil equipment industry for more than 20 years, and France is now the second leading exporter of petroleum technology and equipment. Cooperation between the government and private industry was instrumental in achieving this position. French policymakers have believed that a large and technically advanced oil industry would help France open up access to foreign oil resources and improve the security of its oil supply position. Overall French Government support for the development of offshore technology probably exceeds any other government, according to an authoritative industry publication. In the early development of France's offshore industry, the government decided to reduce competition among domestic firms by assigning research functions to specialized agencies. The resulting developments were then licensed to private firms for commercial applications. []

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Much of the new technology and development produced by French industry originates within two major government agencies, Institut Francais du Petrole (IFP) and the French Research Institute for the Exploitation of the Sea (IFREMER), which deal with petroleum and oceanographic research, respectively. Both work closely with the two major French international oil companies, CFP-Total and ELF Aquitaine, and a number of French international and domestic petroleum equipment companies and contractors.

Areas of offshore technology where French industry is now in the forefront include:

- Diving and advanced underwater work (COMEX).
- Flexible pipe (COFLEXIP).
- Directional drilling (CFP-Total, FORAMER).
- Deepwater drilling technology (Elf-Aquitaine, Total).
- Production and subsea technology (ACB).
- Tension leg platforms (G. G. Doris, Bougyues Offshore, CFEM).

Examples of advanced French expertise include the Upper Zakum Project off Abu Dhabi, engineered by Serete, and the 1982 world deep sea drilling record of 1,714 meters set by Elf and Total. Elf, in association with Total and I.F.P., is preparing equipment and procedures for drilling a well in 3,000 meters of water in the Mediterranean, far exceeding the current record drilling depth of 1,965 meters by US Shell in the Baltimore Canyon area off New Jersey.

The French Government recently has been wrestling with severe problems in the French oil service industry caused by the recession in the worldwide oil industry and the lack of competitiveness of some French equipment companies. According to the US Embassy in Paris, sales of French petroleum equipment and services fell from \$9.1 billion in 1982 to about \$6.6 billion in 1983, which was a steeper plunge than most foreign equipment exporters during that depressed period. Creusot-Loire, a major heavy equipment manufacturer, collapsed last year, and a number of other large firms including UIE (offshore platforms) and Technip (engineering services) are in trouble. The US Embassy in Paris reports that, although French suppliers have raised the possibility of government assistance to the industry in the form of new financing schemes to foreign clients, officials do not envision their adoption.

Italy

State-financed companies hold a preeminent position in Italy. The Italian petroleum industry falls under the aegis of Ministry for State Participation, which, in turn, controls two major groups, ENI and IRI. The major petroleum-related entities within ENI are AGIP, the national oil company, SNAM, the national gas company, Saipem and Snamprogetti, competing engineering and construction companies, and Nuovo Pignone, a mechanical manufacturing company. Among the energy-related suppliers within IRI are Finsider in steel production, Fincantieri in ship, platform, and drilling rig manufacturing, and Finmeccanica and Selenia in electronics, control, and automation systems manufacturing. Despite the dominance of large state companies, Italian independents occupy important portions within the industry. Micoperi in Milan and Belleli in Mantua are two large private companies engaged in offshore petroleum design, fabrication, and construction work.

In addition, Tecnomare was founded in 1971 by a group of Italian private and state companies interested in developing marine petroleum technology. Besides innovative deepwater R&D and engineering, Tecnomare is heavily involved in studies of petroleum development in Arctic conditions. The banking group IMI, which heads Tecnomare, is also responsible for managing a state fund to finance applied offshore research.

Major state involvement in all aspects of Italy's petroleum industry has led to significant R&D budgets that have propelled Italian companies to the forefront of many areas of petroleum technology. Major technologies and projects developed by Italian companies include:

- The Transmed gas pipeline designed and constructed by Snamprogetti and Saipem. Italian companies are leaders in offshore pipeline construction and have laid the deepest underwater pipeline in the world—up to 610 meters.
- Tecnomare's design of the largest offshore steel platform in the world for Phillips Petroleum's Maureen field in the United Kingdom.

- Development by AGIP and other Italian companies of Libya's offshore Bouri field—the largest offshore oilfield in the Mediterranean.
- Nuovo Pignone's development and use of the first telemetry system for centralized control of several drilling and process platforms offshore through a command center on land. []

Japan

Japan entered the field of international energy resource development late. Unlike Europe's experience with the North Sea, Japan has no major petroleum provinces to develop. With government assistance, Japanese companies have had to slowly build expertise in the upstream end of the petroleum business. Today, Japanese companies are competitors in many areas of the petroleum equipment industry, although much Japanese equipment—particularly involving drilling and production technology—is based on licences and manufacturing arrangements with US companies. []

The Japan National Oil Corporation (JNOC) was established by the government in 1967 to support and encourage petroleum development initiated in the Japanese private sector. JNOC provides equity capital and loans, guarantees, and other forms of assistance to Japanese oil companies. Further financial assistance is supplied by the Export-Import Bank of Japan, which provides attractive loan rates for companies developing petroleum resources to be imported by Japan. At the end of March 1983, equity capital supplied by JNOC was 42 percent of Japan's entire worldwide exploration and development capital investment of \$1.2 billion. Japan aims to increase the amount of oil supplied through Japanese companies to some 1.2 million b/d in 1995 from the 1984 level of 300,000 b/d. Japanese petroleum equipment manufacturers benefit from Japanese development projects because of Japanese companies' tendencies to rely on indigenously manufactured equipment. []

The Japanese petroleum equipment industry includes both the general trading companies, such as Mitsui, Mitsubishi, Sumitomo, and Nissho Iwai, and multinational manufacturers, such as IHI, Hitachi Zosen, Hitachi, and Toshiba. The interrelationship between these companies is complex, and major projects often involve a number of companies working together.

Japanese trading companies are particularly adept at developing worldwide business opportunities and directing business toward Japanese companies. Some of the trading companies own their manufacturing facilities, while others rely on affiliated companies. General trading companies also do engineering and project management work and have extensive research and development facilities. Mitsui, for instance, has an extensive Arctic ice engineering and construction laboratory. []

Japanese companies are particularly noted for their expertise in petroleum equipment materials and fabrication. Japanese steel companies are world leaders with four companies—Nippon Steel, Nippon Kokan, Kawasaki, and Sumitomo—ranking among the world's top 10 steel producers. The world petroleum industry has relied on the Japanese steel industry for much of the major petroleum equipment fabrication projects, ranging from offshore platforms to 56-inch line pipe. Among the strengths of Japanese companies are quality of product, broad product lines, the ability to form consortiums with other Japanese steel mills to meet large orders, and heavy investment in research and development. []

major thrusts of Sumitomo, Kawasaki, and Nippon Kokan's marketing strategy appear to be increasing emphasis on tubular products and increasing markets in the Soviet Union and China. Nippon Steel is expected to maintain its leading role in the worldwide steel industry and concentrate on developing high value-added products such as tubulars and surface-treated steels. []

Norway

Norwegian policy has been to maintain strict control over oil and gas field development to ensure a steady level of return to the state in capital investment and to provide work for Norwegian fabrication yards and Norwegian suppliers. Oslo's policy also emphasizes the commitment of foreign R&D to Norwegian companies. Between 1979 and 1986 a total of 19 foreign firms will have to put up more than Nkr 2 billion (\$220 million) for some 512 projects under technology agreements signed by the beginning of 1983. As in the case of the United Kingdom, the Norwegians have

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used the oil and gas field licensing procedure to implement these policies. Key criteria in their choice of licenses include:

- Satisfactory participation by Statoil.
- Proof of ability to strengthen the Norwegian economy, industrial growth, and employment.
- The applicant's past promotion of the use of Norwegian goods and services. []

As a result of this approach to industry development and its experience in the North Sea, Norway is becoming a technical leader in several essential offshore technologies, including seismic exploration, drilling, and production, especially in sub-Arctic waters. GECO, a subsidiary of Det Norske Veritas partly owned by the Norwegian Government, is a world leader in the development and use of sophisticated offshore seismic equipment. A number of Norwegian engineering companies, such as Aker Engineering and Kvaerner Engineering, have developed new technologies for deepwater drilling and production. The oil division of Kongsberg Vapenfabrik is planning to become a major force in the production of subsea equipment and is working with a major US company to manufacture equipment for use in the deepwater fields in the North Sea. Kongsberg believes that subsea production will probably expand rapidly over the next five years as virtually every development scheme in Norway's Continental Shelf will involve use of such facilities. Norway is also among the technical leaders in offshore electronics, advanced dynamic positioning, and remotely operated underwater vehicles (ROVs). []

Much of the advanced research in petroleum technology is carried out by Norwegian research organizations whose work is sought worldwide. Det Norske Veritas is becoming a major force as a certifying organization for offshore work and is creating competition for the American Petroleum Institute to the dismay of US equipment suppliers. Foreign interest is high in applying Norwegian expertise to Arctic waters in Canada, Alaska, and the USSR. The Soviet Union recently contracted with Norway's BOCONOR group to sketch a "master plan" for Barents Sea development projects. This plan, comprising both fixed platforms and subsea production units, was presented to the Soviets last year. []

Sweden

Swedish petroleum equipment companies have established a reputation in areas such as manufacturing specialized steels (Sandvik, SKF), submersible technology (Sutec, Kockums) electronics/communications technologies (LM Erickson) and prime movers and compressors (ASEA Stal-Laval). More recently, Gotaverken Arendal (GVA) has emerged as a major competitor in semisubmersible platform design and construction. []

The Swedish Government is particularly interested in research and development in ocean technology and has commenced a three-year national program to develop Swedish qualifications and competence in the field. The government has allocated \$4 million for this program to be managed by the Swedish Board for Technical Development (STU). The areas of offshore technology of particular interest to Sweden include:

- Underwater technology.
- Specialized steel technology for application in sour gasfield development.
- Electronic technology for sensing, control, and data processing.
- Arctic environment technology. []

The National Defense Research Institute (FOA) sponsors a number of underwater technology projects that have petroleum industry applications. Special expertise has been developed in navigation and positioning inside underwater structures, airborne laser bathymetry, obstacle mapping for Arctic shipping routes, seismic exploration, and deep diving. []

United Kingdom

Starting with the early development of the North Sea, London has consistently followed an "open door" policy to encourage multinational oil companies to operate in the United Kingdom as long as they use British supply firms as much as possible. British policy was intended to create a British petroleum equipment industry, which had been essentially nonexistent before 1965. This policy is implemented through the mechanism of licensing of offshore

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blocks. The UK Department of Energy (DOE) judges applicants competitively on the basis of their past or intended contribution to the UK economy and their past performance and future commitment to ensure "full and fair opportunity for the UK industry to compete for orders." []

The DOE controls approval of each development proposal and reviews the percentage of UK content for each component and for the project as a whole. Companies rarely request approval unless they have an acceptably high percentage of UK content—currently in excess of 70 percent. []

The DOE's operational arm, the Offshore Supplies Office (OSO), assigns an auditor to each operating company and a major contractor to work on future projects. OSO also receives quarterly reports after contracts have been let to ensure that UK suppliers have received "full and fair opportunity." Where UK suppliers appear to be uncompetitive, OSO promotes new ventures, advises on marketing arrangements, sponsors R&D, and provides financial assistance in collaboration with regional development authorities. British firms now provide 70 percent of goods and services used in oil and gas projects, up from only 10 percent in 1974, according to press reports. []

The UK Government recently added two equipment industry guidelines designed to improve industry's international competitiveness:

- New offshore licenses are to be directly linked to an applicant's readiness to involve UK industry in new offshore technology and R&D projects.
- OSO and the offshore supply industry will actively seek to promote exports of offshore equipment and services. []

The US Embassy in London reports that OSO has started to implement the government's new policies. In particular, a major US engineering and construction firm found it advisable to form a joint venture with a UK-owned firm to secure work on a very large offshore development project. This firm believes that Britain will henceforth demand similar joint ventures whenever US suppliers seek to obtain high-technology contracts in the UK sector of the North Sea. []

The structure of the UK offshore industry is undergoing significant change from the boom years of the 1970s. It is making the sometimes painful transition from a sector biased toward heavy engineering involving the construction of large offshore platforms in Great Britain to one geared more toward technology and design expertise which can be marketed abroad. Areas identified by OSO for research and development include:

- Marginal oil and gas field development.
- High-pressure deep gasfield development.
- Enhanced oil recovery, gas condensate development, and heavy oil recovery.

The UK Government is also encouraging the further development of subsea and ROV technology and deviated and horizontal drilling in deep water. []

West Germany

West German petroleum equipment companies are a major force in the world petroleum equipment industry. In 1983 West German companies were the largest suppliers to the Soviet Union of machinery and equipment for exploration, production, and pipeline operation equipment—almost \$400 million—and, next to Japan, the second-largest supplier of pipe—almost \$700 million. Among the major contracts, Mannesmann has supplied significant quantities of large-diameter pipe for the Soviet gas pipeline to Western Europe, and AEG Kanis has supplied gas turbine engine parts. []

Annual average sales of the German offshore industry exceed \$600 million with annual increases in sales of all plant, equipment, and services in the offshore sector averaging well above 10 percent over the last five years. Besides the North Sea market, West German companies are concentrating on Southeast Asia and China offshore markets. The West German offshore companies include:

- Major shipyards such as HDW and Blohm & Voss with a comprehensive range of mobile exploration platforms, special-purpose vessels ranging from crane ships to launch barges, deck structures for platforms, accommodation and production modules, and icebreaking vessels of all types.

- Smaller size shipyards, such as the Martin Jansen and Paul Lindenau yards, with special-purpose vessels such as supply vessels of all types, diving support vessels, and geophysical and research vessels.
- Companies in the materials technology sector, such as Thyssen and VDM, with steel grades for all environments including polar conditions.
- Mechanical engineering companies with specialized equipment including Bruker in underwater technology, MTU propulsion and drive systems, and Paguag in flexible pipelines.
- Companies engaged in electrical engineering and electronics, including AEG-Telefunken.

The Federal German Ministry for Research and Technology has provided substantial R&D funds to West German companies in the area of the German ocean engineering industry. In particular, the German Government has been interested in developing:

- Floating and stationary plants for the production and processing of oil and natural gas from marginal offshore deposits.
- Equipment, vehicles, processes, and services in the field of underwater inspection, maintenance, and repair of offshore installations.
- Development of vessels for special offshore duties such as seismic survey and Arctic supply.

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